Form 1220-5
(January 1974)

Filing Code 6763

Date Issued May 1980

Technical Note # 342

TECHNICAL NOTE

U.S. DEPARTMENT OF THE INTERIOR – BUREAU OF LAND MANAGEMENT

THE USE OF GABIONS TO IMPROVE AQUATIC HABITAT

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I. INTRODUCTION

Southwestern Oregon streams flowing from the coast range were noted for their production of salmon and trout. Because of habitat modification and fishing pressure, naturally spawning stocks in these streams have declined. At the same time, demand for fish for the sport and commercial fisheries has continued to climb rapidly. Part of the demand has been met by increased hatchery production. However, it has become clear that the wild stocks are important not only because of their contribution to the fishery, but because of the important genetic diversity they provide and the aesthetic value attached to them. In order to protect and enhance these naturally spawning stocks of wild fish, it has been necessary to rehabilitate habitat lost to human disturbance. This Technical Note describes the use of gabions as part of this rehabilitation effort.

II. BACKGROUND

The low gradient, meandering streams of the Coos Bay District were once prime habitat for anadromous fish and trout. These streams developed in the steep, narrow canyons of the Coast Range, with its high rainfalls and shallow soils. An important part of the habitat in many of these streams was formed by large trees and limbs that fell into the streams, and by large boulders that found their way into the channels. These woody materials and boulders form what is called stream structure, creating pools and cover, and stabilizing the gravels that served as spawning areas.

Disturbance of the coastal streams by timber harvest, access road construction and fire, have altered the habitat in the streams. Timber was removed from the stream corridors so that any structural material which washed out the stream was not replaced. Removal of vegetation, construction of roads, and subsequent erosion, debris avalanches and road and slope failures have caused increases in runoff of precipitation and extensive scouring of stream channels. In many streams, the structure was removed from the channels, and gravels were lost, leaving behind bedrock from which most of the pool area and productive gravels were scoured away. The resultant loss of habitat for the spawning and rearing of anadromous fish and trout contributed to the decline in their populations.

In order to improve the quality of fish habitat, the Coos Bay District considered several possible types of rehabilitation. It was decided to use gabions as a method of replacing some of the lost structure in these streams. The gabions would provide a method for stabilizing spawning gravels by trapping them in the quieter water upstream, while at the same time creating pool habitat in the plunge area below the gabion.

Wire gabions used in aquatic habitat improvement
and enhancement programs in Coos Bay District.

Biologists have been using gabions to improve aquatic habitat for sometime. The Eugene District placed a number of gabions in coastal Oregon streams in 1970 and 1972. These gabions were laid across the stream and perpendicular to the current, and gravel was placed upstream behind the structures.

This design sometimes resulted in bank erosion around the ends, loss of gravel and some gabions rolling over if they were not firmly packed with angular rock. It was found that the stability of gravel placed behind the gabions was somewhat unpredictable but could be improved by placing one gabion upstream and one downstream with gravel in between. Those structures that retained their position, without eroding, functioned in the prescribed manner and have been documented as being utilized by salmon and steelhead year after year (Engles 1975). The plunge-pool areas created below the gabions have also been documented as being extensively used by juvenile salmonids (Hammer 1977).

In the Coos Bay District, gabions have been used for several years to form jump pools at the outlet of culverts to improve passage for salmon and steelhead. Access to five culverts has been improved by the placement of gabions downstream from the culvert out-fall at a point where velocities began to dissipate (Illustration 1, Appendix II). Specific gabion location was based on the deposition of fine bedload at the tail-out of the out-fall pool formed beneath the culvert mouth. The gabions were constructed in a wide "V" formation approximating the "crescent" shape of the pool tail-out. This type of structural formation has been found to be very stable primarily because: 1)the stream flow currents are directed toward the center of the structure and 2) eddies are created along the ends causing bedload materials to be deposited along the stream banks, thus minimizing erosion. The success experienced in using gabions to improve culvert access has provided insight into the possibilities of using similar structures to improve spawning and rearing habitat. A series of "V" shaped gabion structures, designed to improve or enhance spawning and rearing habitat, has been constructed on several of the District's streams. These projects were accomplished during the summers of 1975 through 1978 by the employment of Youth Conservation Corps and Young Adult Conservation Corps personnel.

Gabions constructed by YCC and YACC personnel.

IV. EVALUATION

Gabion construction projects, to date, appear to be quite successful in that 90% of the structures have remained reasonably stable in the channel. It has been observed that a few of the structures have shifted from their original position during the first winter following construction. An analysis of the structures that shifted out of position has provided insight for future gabion designs. It appeared that shifting occurred for one or more of the following reasons: 1) they were not adequately anchored into the channel, 2) they were placed in portions of the stream where velocities were too great, 3) they were not properly keyed into the banks or 4) the channel had not stabilized following previous winter debris slides and/or sediment avalanches.

The use of the structures for spawning appeared to be dependent on the ability of the structure to successfully recruit gravel which normally migrated through the system. It was found that some gravel was trapped behind every gabion and rearing pools were formed between each set and below the last gabion in the series. Even those gabions that shifted out of position still managed to trap gravel and form pools. The shifting caused the gabions to function more as a "shunt" than as the "V" shaped gabion drop structure (Illustration 4, Appendix II). Although no studies of salmonid population abundance before and after these projects have been made, young fish have been documented using the newly created habitat. Furthermore, with few exceptions, salmon and/or steelhead adults were observed using these structures for spawning activities.

Winter steelhead spawners utilizing gravel trapped by gabions in Coal Creek.

III. DESCRIPTION

Although each gabion 1/ should be "fitted" according to the contours of the stream channel there is a principal design configuration that should be considered. Series of gabions, similar in function to the "riffle" in the sluice box used by early day miners, were set up in several streams on the District. These gabion series were designed to cause the stream to lose its velocity as it flowed over each structure and the gravel, much like the gold in the miner's sluice box, was deposited in the tail-out of the plunge-pool just prior to reaching the next gabion downstream. 2/ The uppermost gabion in the series usually trapped gravel by recruiting it naturally as it tumbled through the stream system (Illustration 2, Appendix II).

In order to trap gravel and form plunge-pools in the prescribed manner, there was a minimum of two gabions in a series. The first gabion slowed the water by creating a plunge and the second one trapped gravel at the tail-out of the plunge-pool. Each gabion in the series was constructed so that the top of the downstream gabion was slightly higher than the bottom of the one upstream (Illustration 3, Appendix II). The location for gabion sets was based on: 1) stream gradient and width, 2) the need to improve the riffle-pool ratio, 3) the desire to recruit migrating spawning gravels and 4) the need to form rearing pools for juvenile salmonids. It was found that structures worked best in areas where the stream "fanned out" and was 30% to 50% wider than the average width. This resulted in lower velocities and reduced the chances of gabions being rolled out of position from the force caused by winter freshets.

Each gabion in the series was constructed in a "V" formation pointing downstream. To insure stability, most gabions were keyed against boulders or rock ledges along the banks and, when possible, against large boulders in the channel. When necessary, prior to gabion placement, the channel bottom was cleared to obtain a relatively level, firm support for the bottom of the structure. In some cases, the gabions were anchored in place by drilling 2' holes into the bedrock substrata and driving 4' steel fence posts through the center of the gabion. Another method used to reinforce the structure was the use of ½" logging cable run through the structures and tied off to large trees on each bank. One or both of these precautionary measures may be used to insure stability, especially in larger gabion structures.

The largest single gabion structure was constructed using both cable and steel fence posts. It spanned a 48' wide 6th order stream channel. The structure has two wings that are each 30 feet long. Gabion baskets 3 feet wide by 3 feet high by 12 feet long were spliced together and placed in a 18-inch deep trench dug into the stream bottom. The gabions were then filled with 6-inch minus sandstone road base rock mixed with natural sand and gravels from the stream bottom to form a compact unit.

1/ For the purpose of this paper a gabion refers to the two wing "V" structure. There may be 2 or several gabions in a series.

2/ Personnel of the Eugene District found that gabions in the Eugene District set in tandem produced the best gravel entrapment (Engels 1975).

The largest gabion has survived heavy winter freshets and is being used extensively by anadromous fish. The structure filled with gravel the first winter and chinook salmon have completely utilized the entire new spawning area (Illustration 5 Appendix II).

Although gabions have been used primarily to improve or enhance fish habitat, there are other beneficial results of their use. By creating more habitat for fish, the structures may indirectly influence the aquatic invertebrate populations. One of the most obvious results of the use of these structures is an increase in aquatic habitat diversity which should result in a greater diversity of aquatic invertebrates. For example, it was observed that the gravels deposited behind the structures are quickly covered with allochthonous materials which tend to be "trapped" behind the gabion. This material provides an abundant food source and cover for aquatic insects.

Allochthonous material trapped in wire gabions.

Prior to structure placement, most of these allochthonous materials were flushed on through the system and were not present in any one area long enough to be utilized by aquatic organisms inhabiting that particular area. Studies on the numbers of aquatic invertebrates using the habitat created by these gabions have not been conducted to date. It is felt that, in order to determine the total effectiveness (both directly and indirectly) of using gabions to improve or enhance aquatic habitat, perhaps plans should be made to determine changes in the aquatic invertebrate composition both before and after gabion construction.

Gabions have been used not only for improvement and enhancement of aquatic habitat, but also for maintenance of existing habitat. For example, one of the major problems associated with the removal of extensive logjams caused by poor logging practices is the scouring of trapped bedload when too much woody structure is removed. The use of gabions provides an additional benefit in maintaining the existing bedload following stream clearance operations. District fisheries biologists, working on Hogranch Creek, found that gabions could be used to trap redistributed gravels released during logjam removal, thus preventing the subsequent loss of spawning and rearing habitat. In this case, partial clearance of the logjam would have resulted in inadequate fish passage. By placing gabions downstream from the jam area it was possible to remove all of the jam material without losing the positive attributes of channel structure and spawning gravel retention. The Hogranch gabions have proven to be highly successful in functioning in the prescribed manner. The two gabions were set up approximately 30 feet apart and about 75 feet downstream from the jam removal area (Illustration 2, Appendix II). They were completely filled with bedload during the first winter freshets and the gravel deposits have been used extensively by salmon and steelhead spawners every winter since construction.

V. SUMMARY

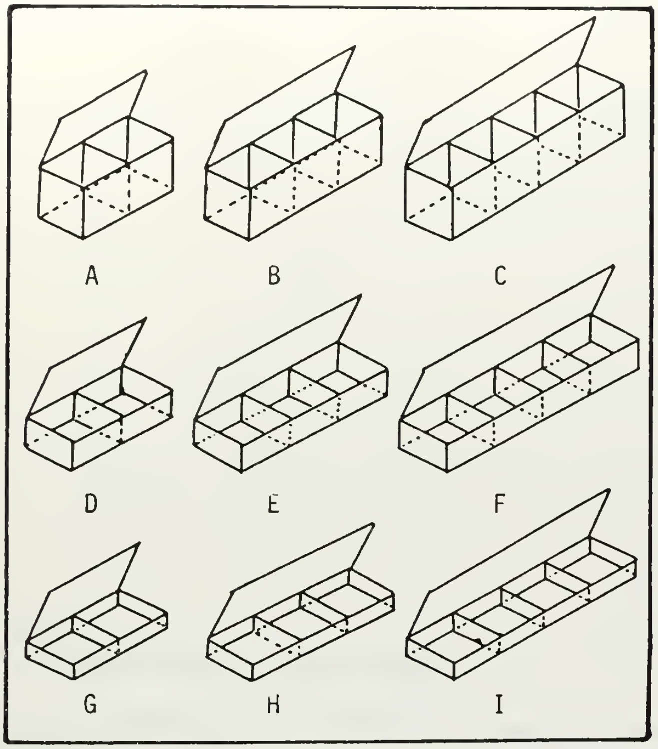
The gabions installed in the Coos Bay District have, with few exceptions, proven to be successful. Those gabions which did not function entirely as intended have provided fisheries biologists with insight concerning the problems encountered using gabions during habitat improvement or enhancement projects.

Project inspections and evaluations have indicated that although some of the gabions "shifted" from their original positions, they have continued to remain functional in adding structure to the stream resulting in gravel entrapment and pool formation. Some of the gabions didn't completely fill with gravel; however, all of them trapped enough gravel to improve the spawning habitat or create new spawning habitat where none had previously existed.

It has been found that the major criteria for success in the utilization of gabions lies in the proper design and placement of these instream structures. In the Coos Bay District, gabions have proven to be quite successful in re-establishing channel structure that had been destroyed by logging activities, intensive stream clearance, or debris avalanches. Gabion construction in the Coos Bay District is considered quite successful because: 1) most of the gabions have remained in position following two seasons of winter freshets,

2) spawning gravels were trapped in every series of gabions installed, and utilized in most, 3) the gabions have created pool areas currently being used by juvenile salmonids and aquatic invertebrates, 4) the structures have proven to be quite durable in that none have fallen apart even though some have rolled or shifted and 5) a data base is being formed to aid fisheries biologists in designing future instream structures, thus increasing the chances of producing the desired results.

APPENDIX I



	Dimensions in feet	No. of Cells	Capacity Cubic Yards
A	6x3x3	2	2
B	9x3x3	3	3
C	12x3x3	4	4
D	6x3x1½	2	1
E	9x3x1½	3	1.5
F	12x3x1½	4	2
G	6x3x1	2	.66
H	9x3x1	3	1
I	12x3x1	4	1.33

GABIONS

Description

Gabions used in the projects described in this paper are rectangular baskets of heavily galvanized steel wire mesh. They were filled with angular 6" minus or river run sandstone to form the definite rectangular units desired. The gabions were carried to the site in pickups where they were unfolded and assembled by wiring the edges together and the diaphragms to the sides. The individual gabions were then wired to each other to form units. The only tools used were 8" pliers, heavy gauge wire cutters and a pinch bar for closing the baskets.

Supply and Delivery

The gabions were supplied by the vendor folded flat and stacked in bundles of five. A flat coil of required lace wire was packed in the bundles.

Mesh and Diaphragms

Gabions used in this work were manufactured of hexagonal triple twist steel wire mesh 3" x 4" approximately running at right angles to the long axis of the gabion. The mesh is reinforced at all edges with a thicker selvage rod. Each gabion is divided into cells by the diaphragms.

Wire Specifications

The vendor supplied gabions that were made of wire mesh that exceeded Federal specification requirements (QQ-W-461g). The wire of the selvage rod has a diameter of not less than 0.150" U.S. gauge 9.

Footnote: This information was adapted from Leaflet MN-602 of Maccaferri Gabions of America Inc., of Flushing New York.

Illustration 1. Narrative.

The culvert at the mouth of Shotgun Creek blocked anadromous fish passage for 15 years. The culvert was replaced on a proper grade but due to the solid bedrock underlaying the pipe a one and a half foot drop still remained. In order to provide a stable entry pool to the culvert a "V" gabion was constructed with labor of a boy scout troop in one day using 6" minus crushed road rock. The corners of the gabion "V" were keyed into the banks and large angular rocks were hand placed to give added protection. The structure has been in place for six years and has become an integral part of the pool tail-out. Silt and gravel deposits in the corners now have alder and willow ten feet high growing on them and most of the structure is incorporated into a bar of large rubble. Coho salmon and winter steelhead adults have been observed using the stream above the culvert for spawning every year since the correction was made.

Illustration 1.

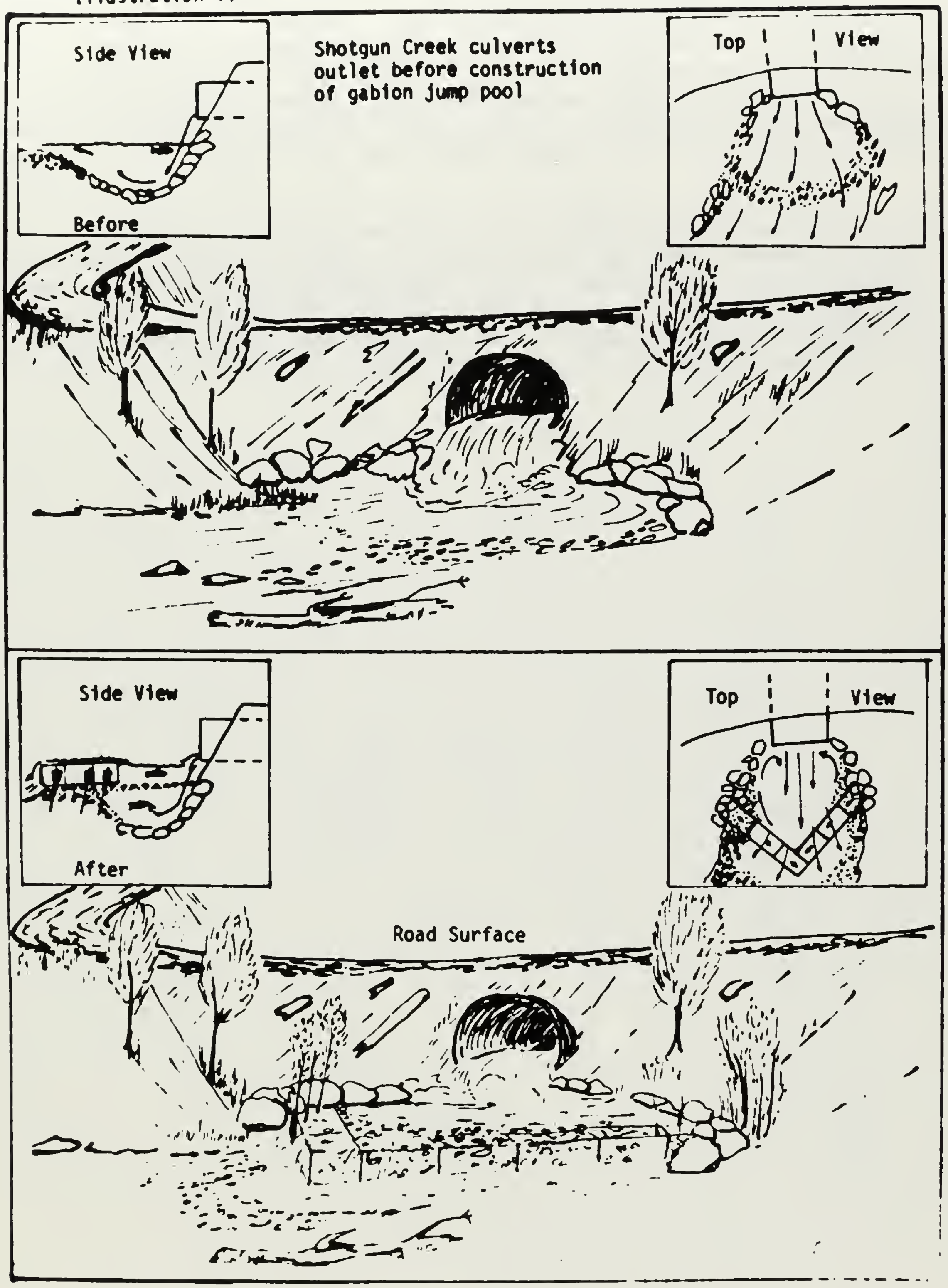
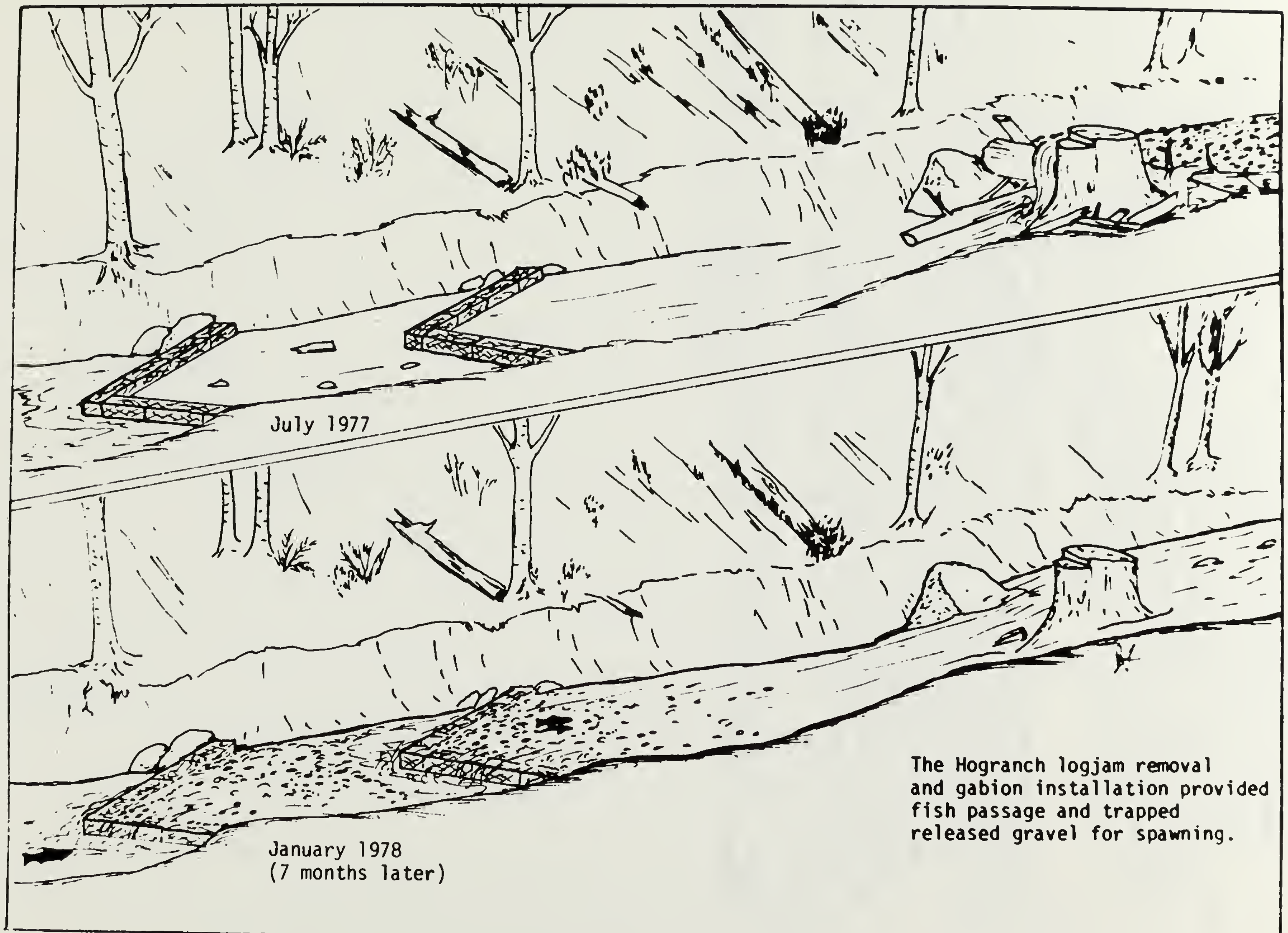


Illustration 2 Narative.

The gabions constructed in July of 1977 by Youth Conservation Corp personnel used the "V" design. The logjam located upstream was observed in 1976 to be totally blocking winter steelhead migration. A substantial amount of gravel and silt was located behind the logjam and if redistributed could provide needed spawning area. The gabions were installed with the purpose of trying to entrap the bedload that was released after the logjam removal. This idea had never been tried before in the District but appeared feasible.

The gabion completely filled the first winter with the bedload from the jam as predicted. Winter steelhead and Coho salmon have been observed using this gravel for spawning every winter since. The structure has remained totally stable. The gabions used were 18" high x 12' long and 3' wide on each wing. Native river rock was used to fill the structures. They were built by a crew of 12 YCC in one day following the clearance operation.

Illustration 2.



The Hogranch logjam removal
and gabion installation provided
fish passage and trapped
released gravel for spawning.

Illustration 3 Narrative.

It was found that the gabions functioned best when placed in sets of at least two. The upstream gabion slows the current and creates a plunge which dissipates the stream energy. This results in a digging action below the upper gabion that usually creates a "plunge-pool" and a deposition of bedload at the tail-out of the pool. 1/ The downstream gabion acts to catch and hold the bedload that is settling out downstream from the first gabion and its' "plunge-pool". It was observed that the height of the downstream gabion should be approximately six inches higher than the base of the upstream gabion in order to trap spawning gravel.

Engels (1975) also found that gabions placed in series ("tandem arragements") worked best to dissipate stream energy and hold gravel. He also noted that the gradient between the top of one gabion and the top of the next should be about one-half percent and the stream gradient should be between two to four percent for best stability. These data correspond closely with the series shown in Illustration 3 with the exception of the gradient between the tops of the two gabions. Engels used a twelve inch high gabion for the upper unit instead of the eighteen inch one used in the Coos Bay District which creates a higher plunge and may produce greater stream energy dissipation.

1/ The substrata of the channel will influence the plunge-pool size. Solid sandstone will not result in a plunge-pool while deep gravels or rubble may produce a large plunge-pool.

Illustration 3. Typical Plan and Profile of a gabion series

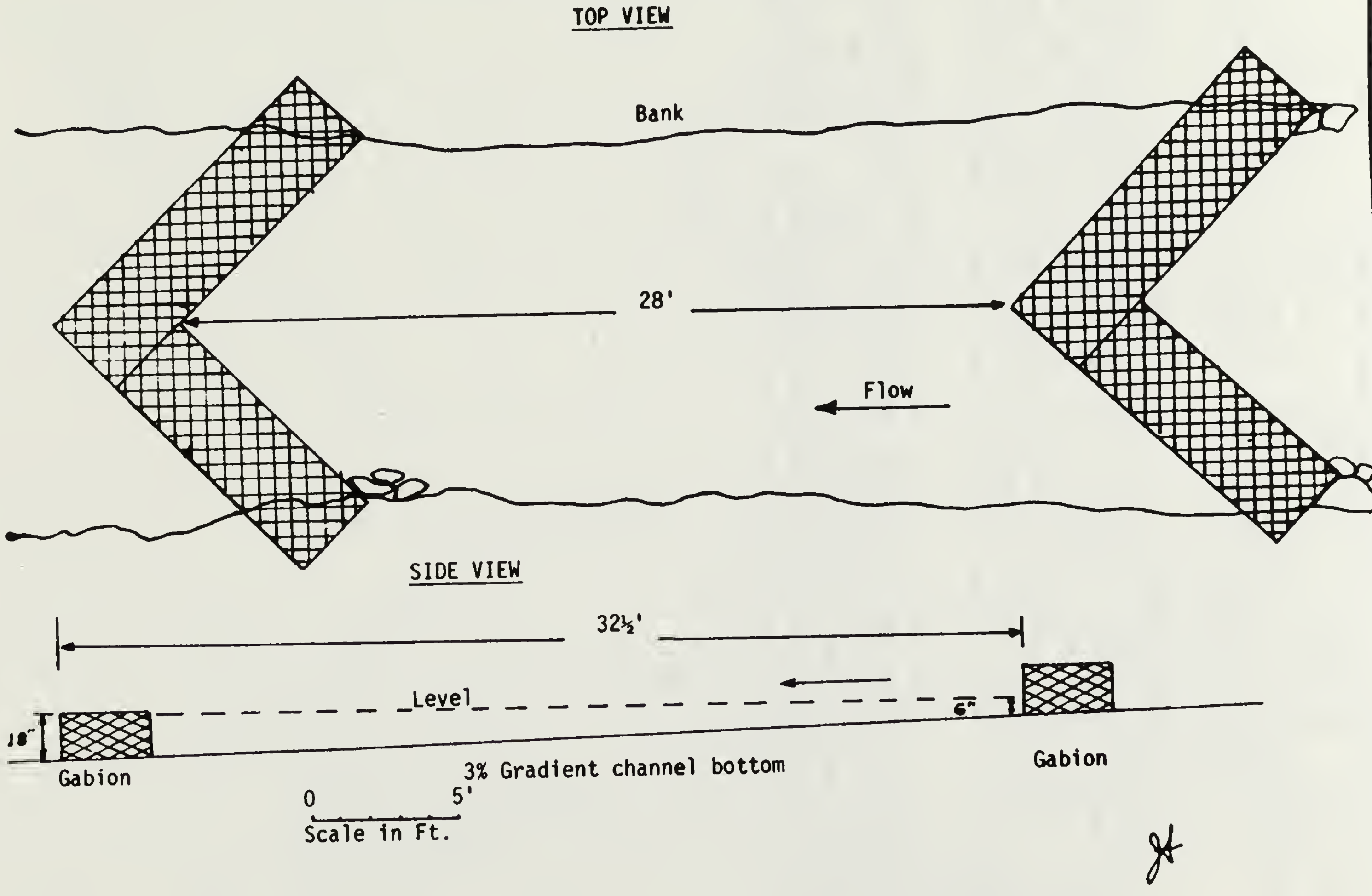


Illustration 4 Narrative.

Shotgun Creek has a relatively narrow channel with a gradient that is moderate to steep. The gabions were constructed in a relatively flat gradient reach to trap gravel for anadromous fish spawning. The stream was scoured by a debris torrent in the winter of 1972 which removed nearly all of the gravel and woody debris capable of holding gravel bars in the channel. Several logjams in the upper reaches of the channel blocked fish passage but retained large quantities of gravel.

The gabions shown in Illustration 4 were constructed to take advantage of the expected release of gravel following logjam removal. The gabions were constructed by Youth Conservation Corp personnel in one afternoon (July 1977). They were not pinned or cabled in place. This series was constructed as a test variation to determine whether minimum attachment using the "V" formation would be adequate. An effort was made to place them in such a way that they would key to the channels own structures such as banks or boulders.

The first winter freshets shifted the gabion in the center of the series to its present position. The downstream gabion twisted and settled but retained its basic position. After this first storm event the gabions have remained stable as has been typical of most gabions constructed in the District. Coho salmon and winter steelhead have used the gravel for spawning and juveniles are found rearing in the pools every year since construction.

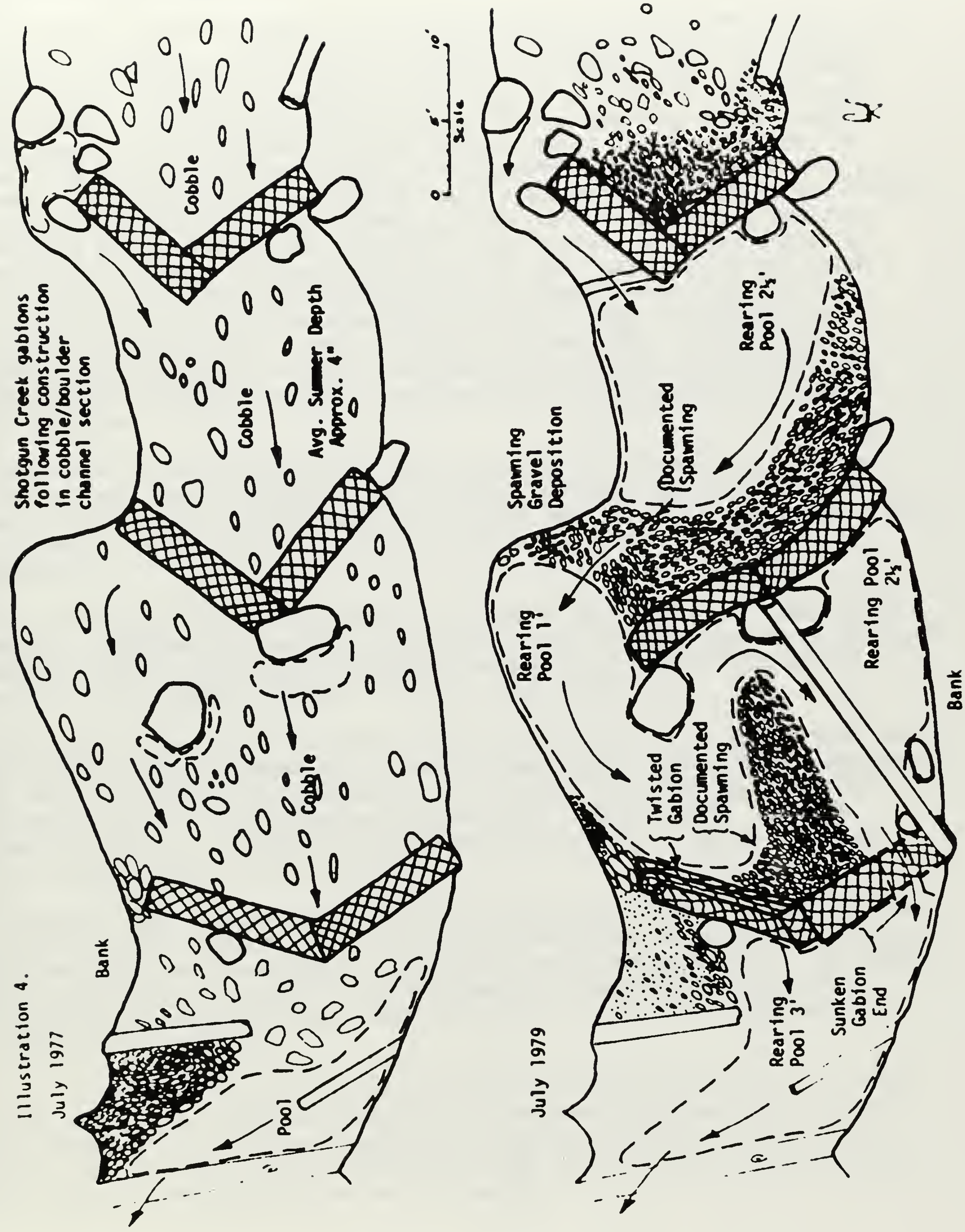


Illustration 4.

Illustration 5 Narrative.

The large Tioga Creek gabion was constructed during the summer of 1978 with several purposes. The stream is a sixth order segment that is used by an increasing number of fall chinook salmon but spawning gravel for chinook is limited. The major spawning bar located at 1+00 was located by Oregon Department of Fish and Wildlife personnel during spawning ground counts. The channel reach upstream from the bar was unused by salmon because it was in a deep quiet reach. Gravel was plentiful on the bottom of this unused reach. Biologist of the ODF&W and BLM agreed that if the stream channel could be modified to provide spawning riffle chinook production could be enhanced and a technique for improving other similar areas could then be available. A major purpose was also to test the stability of the gabion "V" in such a large stream (6th order). Consideration was given to constructing a series with the downstream gabion at 2+00 in order to trap gravel at the tail-out of the first gabion plunge-pool. Only a single gabion was constructed because there was uncertainty about the effects on the channel modifications might have downstream at the existing natural spawning bar.

The gabion has two wings each 30 feet long. Three feet wide by three feet high baskets were trenched one and one-half feet into the gravel bottom and filled with hand packed àngular 6" minus road base rock and stream gravels. A training wing was constructed along the soft alluvial left bank for protection.

The right bank was solid sandstone and required no protection. Steel fence posts 6' long were driven into the bottom of the gabions every three feet and one-half inch logging cable was strung through the length of the entire structure and tied to the base of trees on each bank.

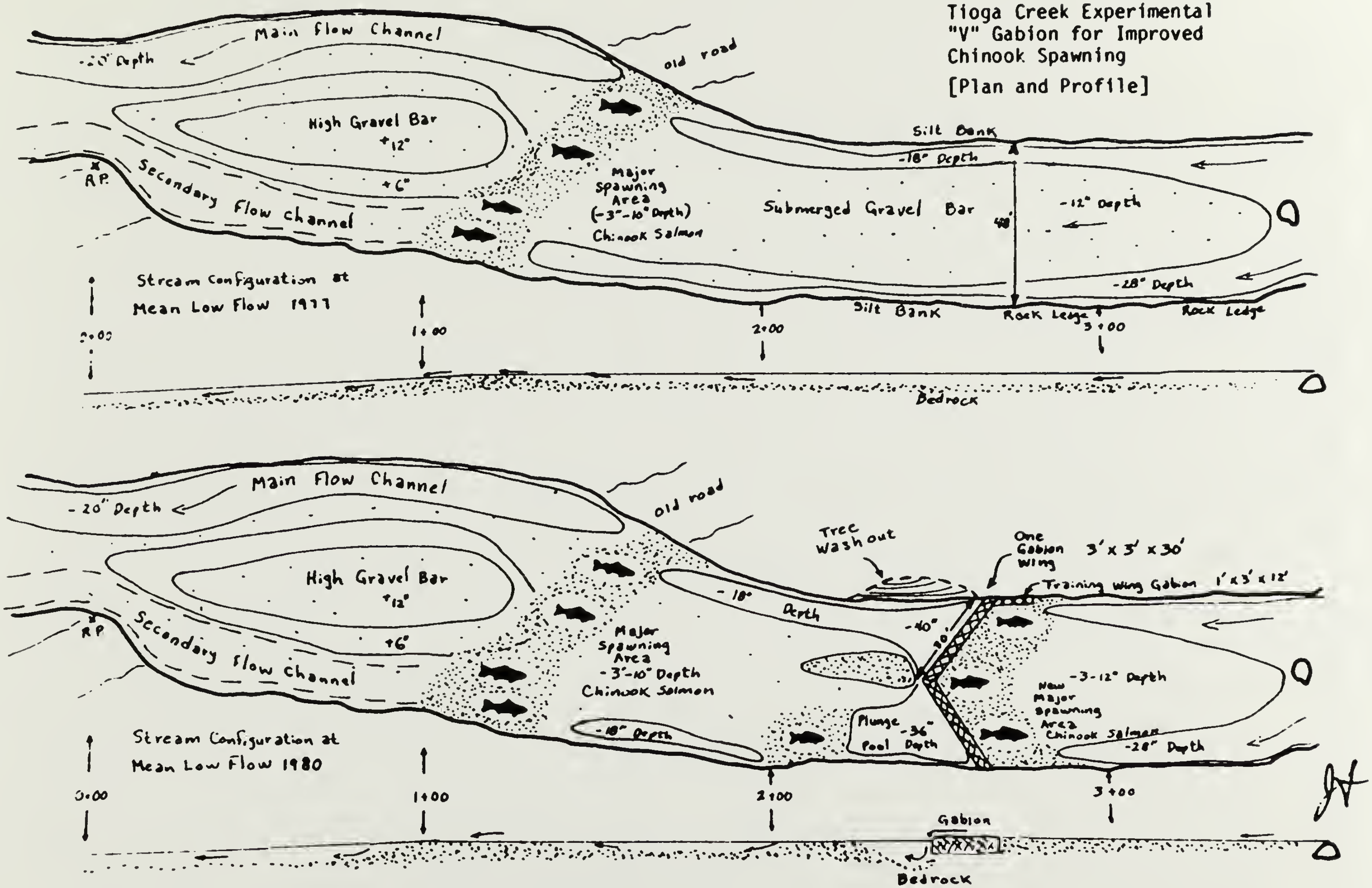
The gabion slowly filled the first winter of 1978-79 and by spring some late winter steelhead attempted to dig beds in the gravel. Chinook were observed on the structure but no spawning was verified. During the fall of 1979 a large run of fall chinook salmon entered Tioga Creek in three distinct spawning waves. Fish from each wave spawned extensively on the gabion in the locations shown in the illustration.

It appears that a second gabion could be constructed at 2+00 without disturbing the natural spawning bar. This would enhance the small spawning bar now located below the plunge-pool of the gabion and create another set of plunge-pools above the natural bar. During spawning it was observed that the chinook extensively used the plunge-pools for cover during disturbance by observers and predators.

The only unplanned occurrance that developed was the washing out of a large alder tree on the left bank immediately downstream from the gabion. This was caused by a slight sag of an inch or two that was built into the wing during construction. This shunted more water into the bank than previously. The alder did not adversely affect the gabion.

Illustration 5.

Tioga Creek Experimental
"V" Gabion for Improved
Chinook Spawning
[Plan and Profile]



It did provide excellent hiding cover for fish during the spawning process. Future construction however should take care to insure bank protection by running exact level lines that would preclude any such sags.

The structure has undergone numerous major storm events and has remained totally stable with no evidence of shifting.

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